FIND-S Algorithm

Example Problem

Example	Eyes	Nose	Head	Fcolor	Hair	Smile
1	Round	Triangle	Round	Purple	Yes	yes
2	Square	Square	Square	Green	Yes	NO
3	Square	Triangle	Round	Yellow	Yes	yes
4	Round	Triangle	Round	Green	No	NO
5	Square	Square	Round	Yellow	Yes	Yes

$h_0 = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$ — 5 attributes

$x_1 = (\text{Round}, \text{Triangle}, \text{Round}, \text{Purple}, \text{yes})$ — +ve example

$h_1 = (\text{Round}, \text{Triangle}, \text{Round}, \text{Purple}, \text{yes})$

$x_2 = (\text{Square}, \text{Square}, \text{Square}, \text{Green}, \text{Yes})$

(-ve example → Ignore it)

$h_2 = h_1$ ie $h_2 = (\text{Round}, \text{Triangle}, \text{Round}, \text{Purple}, \text{Yes})$

$x_3 = (\text{Square}, \text{Triangle}, \text{Round}, \text{yellow}, \text{Yes})$

(+ve example)

$h_3 = (?, \text{Triangle}, \text{Round}, ?, \text{Yes})$

$x_4 = (\text{Round}, \text{Triangle}, \text{Round}, \text{Green}, \text{No})$

(-ve example → Ignore it)

$h_4 = h_3$ ie $h_4 = (?, \text{Triangle}, \text{Round}, ?, \text{Yes})$

x_5 = (Square, Square, Round, Yellow, Yes) — +ve example

h_5 = (?, ?, Round, ?, Yes)

Final hypothesis is h_5 = (?, ?, Round, ?, Yes)

FIND-S Algorithm

Example Problem

Example	Marks	Attendance	Project	Eligible
1	High	Good	Done	Yes
2	High	Average	Done	Yes
3	Low	Good	Done	No
4	High	Good	Not Done	Yes

$h_0 = (\phi, \phi, \phi)$ — 3 attributes

x_1 = (High, Good, Done)

(+ve)

h_1 = (High, Good, Done)

x_2 = (High, Average, Done)

(+ve)

h_2 = (High, ?, Done)

x_3 = (Low, Good, Done)

(-ve) → Ignore it

$h_3 = h_2 \Rightarrow h_3$ = (High, ?, Done)

x_4 = (High, Good, Not Done)

(+ve)

h_4 = (High, ?, ?)

Final Hypothesis is h_4 = (High, ?, ?)

FIND-S Algorithm

Example Problem

Example	Degree	Experience	Skills	Selected
1	B.Tech	2	Python	Yes
2	B.Tech	3	Python	yes
3	B.Sc	2	Python	NO
4	B.Tech	2	Java	Yes

$h_0 = (\emptyset, \emptyset, \emptyset)$ — 3 attributes

$x_1 =$ (B.Tech, 2, Python)

(+ve example)

$h_1 =$ (B.Tech, 2, Python)

$x_2 =$ (B.Tech, 3, Python)

(+ve)

$h_2 =$ (B.Tech, ?, Python) Compare x_2 with h_1

$x_3 =$ (B.Sc, 2, Python)

(-ve example → Ignore it)

$h_3 = h_2$ ie $h_3 =$ (B.Tech, ?, Python)

$x_4 =$ (B.Tech, 2, Java) — +ve example

$h_4 =$ (B.Tech, ?, ?)

The Final Hypothesis $h_4 =$ (B.Tech, ?, ?)

FIND-S

Example Problems

* FIND-S Algorithm is used for finding a maximum specific hypothesis.

Example	citations	size	in library	price	editions	bu
1	some	small	no	affordable	many	no
2	many	big	no	expensive	one	ye
3	some	big	always	expensive	few	no
4	many	medium	no	expensive	many	ye
5	many	small	no	affordable	many	ye

Step1 :

$h_0 = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$

Step2 :

$x_1 =$ (some , small, no, ~~expensive~~ affordable , many)

(-ve example → ignore it)

$h_1 = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$ $(h_1 = h_0)$

$x_2 =$ (many, big, no, expensive, one)

(+ve)

$h_2 =$ (many, big, no, expensive, one) x_2 co

with

x_3 = (some, big, always, expensive, few)

(-ve example → ignore it)

$h_3 = h_2$ i e

h_3 = (many, big, no, expensive, one)

x_4 = (many, medium, no, expensive, many)

(+ve example

h_4 = (many, ?, no, expensive, ?)

x_5 = (many, small, no, affordable, many)

h_5 = (many, ?, no, ?, ?)

Final hypothesis is h_5 = (many, ?, no, ?, ?)

FIND-S

1)

Ex	eyes	nose	head	Fcolor	hair	Smile
1	Round	Triangle	Round	Purple	Yes	Yes
2	Square	Square	Square	Green	Yes	NO
3	Square	Triangle	Round	Yellow	Yes	Yes
4	Round	Triangle	Round	Green	NO	NO
5	Square	Square	Round	Yellow	Yes	Yes

$h_0 = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$ — 5 attributes

x_1 = (Round, Triangle, Round, Purple, Yes)
(+ve example)

h_1 = (Round, Triangle, Round, Purple, Yes)

x_2 = (Square, Square, Square, Green, Yes) — -ve (-ve) Ignore it

$h_2 = h_1$

h_2 = (Round, Triangle, Round, Purple, Yes)

x_3 = (Square, Triangle, Round, Yellow, Yes)
(+ve example

h_3 = (?, Triangle, Round, ?, Yes)

x_4 = (Round, Triangle, Round, Green, NO)

(-ve) —. Ignore

h_4 = (?. Triangle, Round, ?, Yes) $h_4 = h_3$

x_5 = (Square, Square, Round, Yellow, Yes) ~~Yes~~
(+ve)

h_5 = (?, ?, Round, ?, Yes)

Hence, the maximally Specific hypothesis is :

(?, ?, Round, ?, Yes)

Find-s

Example	Marks	Attendance	Project	eligible
1	High	Good	Done	Yes
2	High	Average	Done	Yes
3	Low	Good	Done	No
4	High	Good	Not Done	Yes

(High, ?, ?)

$h = (\phi, \phi, \phi)$

$x_1 = <high, Good, Done>$

$h_1 = <high, Good, Done>$

$x_2 = <high, Average, Done>$

$h_2 = <high, ?, done>$

$x_3 \rightarrow$ no change

$h_3 = <high, ?, done>$

$x_4 = <high, good, not done>$

$h_4 = <high, ?, ?>$

3)

Example	Degree	Experience	Skills	Selected
1	BTech	*	Python	Yes
2	BTech	3	Python	Yes
3	BSc	2	Python	NO
4	BTech	2	Java	Yes

$h = (\phi, \phi, \phi)$

$x_1 = <$ BTech, 2, Python $>$

$h_1 = <$ BTech, 2, Python $>$

$x_2 = <$ BTech, 3, Python $>$

$h_2 = <$ BTech, ?, Python $>$

$x_3 \rightarrow$ no change

$h_3 = <$ BTech, ?, Python $>$

$x_4 = <$ BTech, 2, Java $>$

$h_4 = <$ BTech, ?, ? $>$

Inductive learning:

From the examples we derive rules.

By seeing some real life examples we define our rules.

Deductive learning:

Already existing rules are applied to our examples.

Biased hypothesis space:

Does not consider all types of training examples.

Solution → Include all hypothesis

Ex: Sunny (∧) warm ∧ normal ∧ strong ∧ cool ∧ change ⇒ Yes

and (conjunction)

Unbiased hypothesis space

Providing a hypothesis capable of representing set of all examples.

Possible instances: $3 \times 2 \times 2 \times 2 \times 2 \times 2 = 96$ (3 different values) in sky)

Target concepts: 2^{96} (huge)

These hypothesis are not possible practically.

Inductive Bias:

Learner will be generalized beyond the observed training examples for new examples.

'>' → inductively inferred from

$x > y \Rightarrow$ y is inductively inferred from x.

from 'x' we are defining 'y'.

Ex:

learning alg = L

training data $D_c = \{ x_i, c(x_i) \}$

New instance = x_i;

Represented as $L(x_i, D_c)$

learning alg

$(D_c \wedge x_i) > L(x_i, D_c)$

Candidate Elimination Algorithm

→ It is used to find consistent hypothesis

Example	Sky	Air Temp	Humidity	Wind	Water	Forecast
1	Sunny	Warm	Normal	Strong	Warm	Same
2	Sunny	Warm	High	Strong	Warm	Same
3	Rainy	Cold	High	Strong	Warm	Change
4	Sunny	Warm	High	Strong	Cool	Change

Most specific hypothesis $S_0 = \{\phi, \phi, \phi \cdots >$

a generic hypothesis $G_0 = \{?, ?, ?, ?, ?, ?\}$

For positive samples, we need to move from Specific to general.

For negative samples, we need to move from general to specific

$S_0 = \{\phi, \phi, \phi, \phi, \phi, \phi\}$

$G_0 = \{?, ?, ?, ?, ?, ?\}$

1) Check whether x_1 is +ve (specific to general)

As we dont have no predefined hypothesis

$S_1 = \{$'Sunny', 'warm', 'normal', 'strong', 'warm', 'same'$\}$

$G_1 = \{?, ?, ?, ?, ?, ?\}$

2) +ve - specific to general

Example 2 compared with S_1,

$S_2 = \{ \text{'Sunny'}, \text{'warm'}, ?, \text{'strong'}, \text{'warm'}, \text{'same'} \}$

$G_2 = \{ ?, ?, ?, ?, ?, ? \}$

G_2 (general hypothesis will remain same until and unless we get -ve example

3) $S_3 = \{ \text{'Sunny'}, \text{'warm'}, ?, \text{'strong'}, \text{'warm'}, \text{'same'} \}$

As ex 3 is -ve, change generic to specific

So S_3 will not be changed. It is taken from S_2.

Compare ex 3 with ex 3

Ex 3 → { Rainy, Cold, High, Strong, Warm, Change }

If any change in ex 3 data you need to represent value which is in S_3.

ex 3 = { 'Sunny', 'warm', High, 'strong', 'warm', 'same' }

$G_3 = \{ \langle \text{'Sunny'}, ?, ?, ?, ?, ? \rangle, \langle ?, \text{'warm'}, ?, ?, ?, ? \rangle$

$\langle ?, ?, ?, ?, ?, \text{'same'} \rangle$

4)
(+ve) ⟶ specific to general

S_4 ⇒ S_3 compare with Ex 4

S_4 = { 'sunny', 'warm', ?, 'strong', ?, ? >
if value matches same infn is written
" " doesn't match then replace with ?

~~G_4~~ = As it is +ve value same G_3 data should be written but same is not present in S_4 we need to remove 'same' attribute from G_3.

G_4 = { '<sunny', ?, ?, ?, ?, ? > < ?, 'warm', ?, ?, ?
?>}

S_4 and S_4 are final hypothesis

Candidate Elimination Algorithm

Example Problem

Size	color	Shape	class / Label
Big	Red	Circle	No
small	Red	Triangle	No
small	Red	Circle	Yes
Big	Blue	Circle	No
small	Blue	circle	Yes

$S_0 = (\emptyset, \emptyset, \emptyset)$

$G_0 = (?, ?, ?)$

$x_1 \rightarrow$ −ve example — No change

$S_1 = (\emptyset, \emptyset, \emptyset)$

$x_1 = (big, red, circle)$

As it big we need to check another minimal specializations.

There is another value "small".

$G = \{ \langle small, ?, ? \rangle, \langle ?, Blue, ? \rangle \langle ?, ?, Triangle \rangle \}$

Why Blue: As there is no other possible value, we will replace Red with Blue

Why Triangle: As there is Yes and No for "Circle", we can write minimal

Possible way : e triangle

$\therefore G_1 = \{ \langle small, ?, ? \rangle \langle ?, Blue, ? \rangle$

$\langle ?, ?, Triangle \rangle \}$

Ex 2 x_2 - (Small, red, triangle) → Negative example

$S_2 = (\emptyset, \emptyset, \emptyset)$

$G_2 = \{ (?, Blue, ?) \}$

— As small and Triangle are not

Compare with G_1 with Ex 2 to get G_2.

Ex 3 $x_3 =$ (small, red, circle)

(+ve example.

$S_3 =$ (small, red, circle)

$G_3 = \{ \}$ → when you compare G_2 with S_3 not attributes are matched.

Candidate elimination cannot allow G to be empty, because G must represent all maximally general hypothesis consistent with data so far.

Whenever G is empty, candidate elimination algorithm will not allow. It generates new hypothesis by excluding previous -ve examples.

-ve examples

x_1 — (Big, red, circle)

x_2 - (Small, red, triangle)

So, Size ≠ Big

Shape ≠ Triangle

Color must be Red (from positives)

S_3 = (small, red, circle)

1) Generalize color

(small, ?, circle)

check with negative examples

x_1 — (Big, red, circle)

x_2 - (small, red, triangle)

Size, shape — mismatch

so it is valid.

2) Generalize size

(?, Red, circle)

x_1 — Big, red, circle)

CANDIDATE ELIMINATION ALGORITHM

Income	Credit History	Employment	Approve
High	Good	Permanent	Yes
Medium	Good	Permanent	Yes
Low	Bad	Temporary	NO
Medium	Bad	Temporary	NO

$S_0 = (\phi, \phi, \phi)$

$G_0 = (?, ?, ?)$

$S_1 = (High, Good, Permanent)$ +ve example

$G_1 = (?, ?, ?)$

$S_2 = (?, Good, Permanent)$ S_2 Compare with S_1

(+ve example)

$G_2 = (?, ?, ?)$

$S_3 = (?, Good, Permanent)$

As it is -ve example $\boxed{S_3 = S_2}$

$G_3 = (\langle Medium, ?, ? \rangle \langle ?, Good, ? \rangle \langle ?, ? Permanent \rangle)$

As Medium is not present in S_3, we can eliminate.

$\therefore G_3 = (\langle ?, Good, ? \rangle \langle ?, ?, Permanent \rangle)$

x_4 - -ve example (Medium, Bad, Temporary)

S_4 — (?, Good, Permanent)

S_4 is not changed $\boxed{S_4 = S_2}$

$G_{3_1} = \{ \langle ?, Good, ? \rangle, \langle ?, ? \ Permanent \rangle \}$

G_4 = remains unchanged = G_3

$S_4 = (?, Good, Permanent)$

$G_4 = \{ \langle ?, Good, ? \rangle \ \langle ?, ? \ Permanent \rangle \}$

Candidate Elimination Algorithm

Example Problem

Example	Citations	Size	In Library	Price	Editions	Buy
1	Some	Small	No	Affordable	One	No
2	Many	Big	No	Expensive	Many	Yes
3	Many	Medium	No	Expensive	Few	Yes
4	Many	Small	No	Affordable	Many	Yes

S_4 = (Many, ?, No, ?, ?) G_4 = (Many, ?, ?, ?, ?)

S_0 = (ϕ, ϕ, ϕ, ϕ, ϕ)

G_0 = (?, ?, ?, ?, ?)

Ex-1 : -ve example

S_1 = (ϕ, ϕ, ϕ, ϕ, ϕ)

As ϕ doesn't match with Some, Small, No, ...

G_1 = As we know general hypothesis '?' matches with any value - so it is +ve classification. But ex-1 is -ve result. So find out possible hypothesis by replacing one value at single time with opposite value.

∴ G_1 = (Many, ?, ?, ?, ?) (?, Big, ?, ?, ?) (?, Medium, ? ? ?)

(? ? ? Exp, ?) (? ? ? ? Many) (? ? ? ? Few)

S_1 = (ϕ, ϕ, ϕ, ϕ, ϕ)

Ex-2 — +ve example

S_2 = (Many, Big, No, Expensive, Many)

G_2 = (Many, ?, ? ? ?) (? Big ? ? ?) (? ? ? Exp ?)
(? ? ? ? Many)

(Few, medium doesn't match)

Ex-3 — +ve example

G_3 = (Many, ? ? ? ?) (? ? ? Exp ?)

S_3 = (Many, ?, No, Exp, ?)

(Few, Big doesn't match so removed)

Ex-4 — +ve example

G_4 = (Many, ? ? ? ?)

(Exp doesn't match)

S_4 = (Many, ?, No, ?, ?)

∴ G_4 = (Many, ?, ? ? ? , ?)

S_4 = (Many, ?, No, ?, ?)

Candidate Elimination Algorithm

Income	Credit	Employment	Approve
High	Good	Permanent	Yes
Medium	Good	Permanent	Yes
Low	Bad	Temporary	No
Medium	Bad	Temporary	NO

$S_0 = (\phi, \phi, \phi)$

$G_0 = (? ? ?)$

Ex-1 → +ve

$S_1 = (High, Good, Permanent)$

$G_1 = (? ? ?)$

Ex-2 → +ve

$S_2 = (?, Good, Permanent)$

$G_2 = (?, ?, ?)$

Ex-3 → -ve example

$G_3 \Rightarrow$ All ? matches with values. So +ve Classification but result -ve. So not consistent. find possible hypothesis

$G_3 = (High, ?, ?)\ (Medium, ?, ?)\ (?, Good, ?)\ (? ? Permanent)$

$S_3 = (?, Good, Permanent)$

Ex-4 - ve example.

G_3 = (High, ? ?) (Medium, ? ?) (? Good ?)

(? ? Permanent)

G_4 => ① Medium doesnt match with high

-ve Classification → -ve o/p ✓

② Medium matches with medium

↳ +ve → -ve o/p X

③ Good doesn't match - ve class → -ve o/p ✓

④ doesn't match - ✓

G_4 = (~~Medium~~ (High, ?, ?) (? Good ?) (? ? Permanent)

S_4 = (?, Good, Permanent)

∴ S_4 = (?, Good, Permanent)

G_4 = { (High, ?, ?) (?, Good, ?) (?, ?, Permanent)

Eliminate.

Candidate Elimination Algorithm

Example	Shape	Size	Color	Surface	Thickness	Target
1	Circular	large	light	smooth	thick	Yes
2	Circular	large	light	irregular	thick	Yes
3	Oval	large	dark	smooth	thin	NO
4	Oval	large	light	irregular	thick	Yes

$S_0 = (\emptyset, \emptyset, \emptyset, \emptyset, \emptyset)$

$G_0 = (?, ?, ?, ?, ?)$

Ex-1 — +ve example

$S_1 = (\text{circular}, \text{large}, \text{light}, \text{smooth}, \text{thick})$

G_1 — ? matches with all — +ve classification +ve o/p

$G_1 = (? ? ? ? ?)$

Ex-2 +ve example

$S_2 = (\text{circular}, \text{large}, \text{light}, ?, \text{thick})$

$G_2 = (? ? ? ? ?)$

Ex-3 — -ve example

Ex-3 (oval, large, dark, smooth, thin)

G_3 = All ? matches with all — +ve classification but -ve o/p.

Not consistent. We need to find all possible hypothesis

G_3 = { (Circular, ? ? ? ?) (? ? light ? ?) (? ? ? irregular ? ?

(? ? ? ? thick)

eliminate irregular

S_3 = (Circular, large, light, ?, Thick)

Ex - 4 — +ve example

S_4 = (?, large, light, ?, thick)

G_4 = ① (Circular, ? ? ? ?) — no match remove

② (? ? light ? ?) — match ✓

~~③ (? ? ? irregular ?)~~ — match ✓

④ (? ? ? ? thick) — match ✓

G_4 = ~~(Circular, ? ? ? ?) (? ? light ? ?) (? ? ? irregular ?)~~

(

G_4 = (? ? light ? ?) (? ? ? irregular ?) (? ? ? ? thick)

∴ S_4 = (?, large, light, ?, Thick)

G_4 = { (? ? light ? ?) (? ? ? irregular ?) (? ? ? ? thick)

eliminate

G_4 = (? ? light ? ?) (? ? ? ? thick)

Candidate Elimination Algorithm

Size	Color	Shape	Class
Big	Red	Circle	NO - 1
Small	Red	Triangle	NO - 2
Small	Red	Circle	Yes - 3
Big	Blue	Circle	NO - 4
Small	Blue	Circle	Yes - 5

$S_0 = (\phi, \phi, \phi)$

$G_0 = (?, ?, ?)$

Ex 1 — Negative example

ϕ will not match with big, red, circle. So it is Consistent because expected value is -ve. So no change in S_1.

$S_1 = (\phi, \phi, \phi)$

General hypothesis ie ? matches with big, red, circle so it is +ve classification and expected is -ve, we need to write all hypothesis which makes it as consistent.

We need to write opposite value of value which is present currently.

Big opposite

$G_1 = (Small, ?, ?)(?, Blue, ?)(?, ?, Triangle)$

$S_1 = (\phi, \phi, \phi)$

$G_1 = (\text{small}, ?, ?)\ (?, \text{Blue}, ?)\ (?, ?, \text{Triangle})$

Ex-2 — -ve example

ϕ doesn't match with small, Red, Triangle so its -ve classification, expected is also -ve.

So S_2 remains the same.

ie $S_2 = (\phi, \phi, \phi)$

G_2 :

① (Small, ?, ?) — small matches with small
? " " Red
? " " Triangle

so its +ve classification but expected is -ve

Define possible hypothesis

G_2 : (small, Blue, ?) (small, ?, Circle)
opposite to Red — opp to Triangle

② ϕ ?, Blue, ?)

— ? matches with small

Blue doesn't match with Red — so -ve classification, expected is also -ve. so we will leave as it.

G_2 : (small, Blue, ?) (small, ?, circle) (?, Blue, ?)

G_2 - ③ (?, ?, Triangle)

? matches with Small

? " " Red

Triangle " " Triangle — +ve classification

but -ve o/p. so possible hypothesis need to find. as it is inconsistent.

B. First ? is replaced with opposite value

The value in ex2 is small, we need to replace opposite value ie Big

(Big, ?, Triangle) (?, Blue, Triangle)

∴ G_2 : (small, Blue, ?) (small, ?, Circle) (?, Blue, ?)

(Big, ?, Triangle) (?, Blue, Triangle)

Among these we need to check which hypothesis matches with the examples what we have seen earlier. (it should match with both ex1 & ex2)

G_2 - ① (small, Blue, ?)

ex2 { small matches with small, Blue doesn't match with Red } — so -ve classification, expected is -ve

so consistent.

ex1 (small, Blue, ?)

small doesn't match with Big — so -ve, expected is also -ve

Hardly go with other hypothesis.

G_2 : (small, Blue, ?) (small, ?, circle) (?, Blue, ?)
(Big, ?, Triangle) (?, Blue, Triangle)

Ex-3 - +ve example.

We need to check whether G_2 hypothesis is consistent with ex-3, if it is, remain otherwise remove it.

Ex3 - (small, Red, Circle)

G_2 - ① (Small, Blue, ?)

Small matches with small
Blue doesn't " with Red
} -ve classification but expected +ve

So inconsistent. Remove

② (small, ?, circle) matches with ex3

So consistent. Remains same

③ (?, Blue, ?) ? matches with small
Blue doesn't match " Red
} -ve classification but expected +ve

So inconsistent. Remove it

④ (Big, ?, Triangle) - Big doesn't match with small
? matches with Red
Triangle doesn't match " circle
} -ve classification, but expected +ve

So inconsistent. Remove it.

(5) (?, Blue, Triangle)

? matches with small
Blue doesn't match " Red
Triangle " " " Circle
} -ve classification, but expected is +ve

So inconsistent. Remove it.

So, consistent hypothesis ~~are~~ is

G_3 = (small, ?, circle)

S_3 = (small, Red, Circle)

Ex 4 :- -ve example Ex 4 (Big, blue, circle)

$S_3 \rightarrow$ Ex 4
~~Small~~ doesn't match big
Red " " blue
circle match circle
} -ve classification expected also -ve

So remains same as S_3

∴ S_4 = (small, red, circle)

Big - small → no match, g_4 retains as it is

So $G_4 = G_3$ = (small, ?, circle)

Ex 5: (small, blue, circle) – +ve example

G_4 – (small, ?, circle)

Small matches with small
? " " blue
circle " " circle

} +ve classification result is also +ve

∴ G_5 = (small, ?, circle)

S_5 = S_4 Compare with Ex 5

= (small, ?, circle

S_5 = (small, ?, circle)

G_5 = (small, ?, circle)

Candidate Elimination Algorithm

Attendance	Assignment	Exam Prep	Pass
High	Submitted	Good	Yes
High	Submitted	Poor	Yes
Low	NotSubmitted	Poor	No
High	NotSubmitted	Good	Yes

$S_0 = \langle \emptyset, \emptyset, \emptyset \rangle$

$G_0 = \langle ?, ?, ? \rangle$

$S_1 = (High, Submitted, Good)$ (+ve)

$G_1 = (?, ?, ?)$

$S_2 = (High, Submitted, ?)$ (+ve)

$G_2 = (?, ?, ?)$

-ve example $G_3 = (\langle High, ?, ? \rangle \langle ?, Submitted, ? \rangle)$

$S_3 = S_2$ $\quad S_3 = (High, Submitted, ?)$

$S_4 = (High, ?, ?)$ S_4 - +ve example

$G_4 = (High, ?, ?)$

Candidate Elimination Algorithm

Outlook	Temperature	Wind	Picnic
sunny	Mild	Weak	Yes
cloud	Mild	Weak	Yes
Rainy	Cold	strong	NO
sunny	Hot	Weak	Yes

$S_0 = (\phi, \phi, \phi)$

$G_0 = (? ? ?)$

Ex 1 — +ve example

$S_1 = (\text{Sunny, Mild, Weak})$

$G_1 = (? ? ?)$

Ex-2 : +ve example

$S_2 = (?, \text{Mild, Weak})$

$G_2 = (? ? ?)$

Ex 3 — -ve example

$S_3 = (?, \text{Mild, Weak})$

$G_3 \Rightarrow$ All ? matches with values. So +ve classification but -ve o/p. So inconsistent. We need to find possible hypothesis by replacing with opposite values.

$G_3 : (\text{Sunny}, ? ?)\ (\text{Cloud}, ?, ?)\ (? \text{Mild}, ?)\ (? \text{Hot} ?)$
$(? ? \text{Weak})$

S_3 = (?, Mild, weak)

G_3 = (Sunny, ?, ?) (cloud, ? ?) (? Mild ?)

(? Hot ?) (? ? weak)

Ex 4 — +ve example

S_4 = (?, ?, weak)

G_4 = { (sunny, ?, ?) (?, Hot, ?) (? ? weak) }

∴ S_4 = (?, ? weak)

G_4 = { (sunny, ?, ?) (? Hot, ?) (? ? weak) }

G_4 ⇒ remove sunny & Hot

∴ G_4 = (?, ?, weak)

Candidate Elimination Algorithm

Internet	Devices	Teacher Trained	Adopt
Good	Enough	Yes	Yes
Good	Few	Yes	Yes
Poor	Few	No	NO
Good	Enough	No	Yes

$S_0 = (\phi, \phi, \phi)$

$G_0 = (? ? ?)$

Ex 1 — +ve example

$S_1 = (Good, Enough, Yes)$

$G_1 = (? ? ?)$

Ex 2 — +ve example

$S_2 = (Good, ?, Yes)$

$G_2 = (? ? ?)$

Ex 3 — -ve example

As all ? matches with values. So +ve Classification, result is -ve, so it is Inconsistent.

Find all possible hypothesis by replacing with opposite values

G_3 = (Good, ? ?) / ? Enough ?) (? ? Yes)

S_3 : (Good, ?, Yes)

Ex 4 — +ve

S_4 = (Good, ? , ?)

G_4 = { (Good, ? ,?) (?, enough, ?) }

S_0 = (∅, ∅ ∅)

G_0 = (? ? ?)

Ex 1 — +ve.

S_1 = (∅ ∅ ∅)

G_1 = (small, ? ?) (Red ✗

G_1 = (small, ? ?)

Ex 2 — -ve S_2 = (∅ ∅ ∅)

G_2 = ((? ? Circle)

Ex 3 — +ve

S_3 = small, red, circle

G_3 = (? ? Circle)

Ex 4 — -ve

S_4 = small, red, circle

G_4 = (small, ? ?) (? , red, ?)

Ex 5 +ve

S_5 = (small, ?, circle)

G_5 = (small, ?, ?

Version Space :

It is the subset of hypothesis (H) consistent with the training examples.

$$VS_{H,D} = \{ h \in H \mid \text{Consistent}(h, D) \}$$

H - hypothesis

D - training examples.

$h(x) = c(x)$ — It is consistent

Some of the hypothesis is taken as subset of hypothesis..

c(x) = target function.

Algorithm to obtain Version Space :

(List then eliminate algorithm)

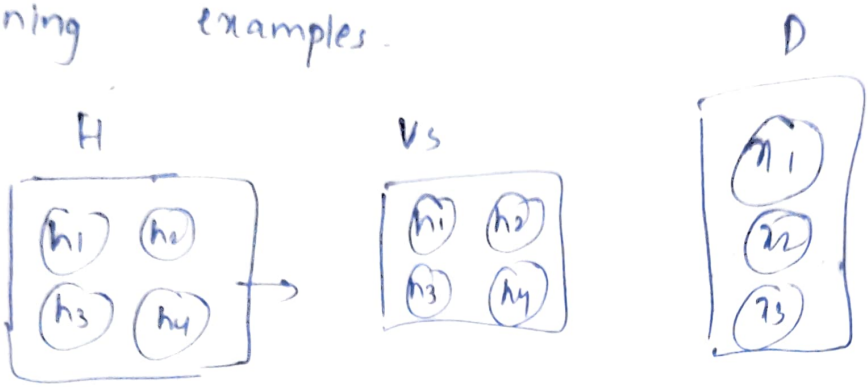
1) Version space ← list containing every hypothesis in H

2) From this step, we keep on removing inconsistent hypothesis from version space

For each training example, $\langle x, c(x) \rangle$ remove any hypothesis that is not.

$h(x) \neq c(x)$

3) O/p the list of hypothesis into Version space after checking for all training examples.



The hypothesis

$h_1(x_1) = c(x_1)$

$h_1(x_2) \neq c(x_2)$ then h_1 is eliminated from version space

$h_1(x_3) \neq c(x_3)$

hypothesis is present in version space if and only if all examples satisfy with hypothesis.

Inductive Bias:

Remarks on Candidate elimination and version space algorithms

1) Will the CE algorithm give us correct hypothesis?

2) What training example should the learner request next?